By FRANK de LEEUW and MICHAEL J. McKELVEY

The Realization of Plans Reported in the BEA Plant and Equipment Survey

PLANS reported in BEA's plant and equipment survey have long provided important indicators of future expenditures on new plant and equipment (P&E). Examination of the relation of these plans to actual expenditures is especially useful at this time because the last comprehensive examination is more than ten years old and because an extensive revision of the P&E survey data was completed in 1980.[1]

The examination undertaken in this article is in two sections. The first section presents summary measures of errors in P&E expenditure (henceforth, investment) plans—defined for this article as discrepancies between plans and subsequently reported actual investment.[2] For two time periods—1957–60 and 1970–80—it analyzes errors by industry-group, by length of planning horizon (one-quarter-ahead, two-quarters-ahead, and year-ahead), and at cyclical turning points. The second section reports on regression relationships of actual investment to plans and to variables that may influence the realization of plans. The latter include constant-dollar (real) final sales, after-tax profits, and investment goods prices.

Most of the data used in the article have been corrected for systematic bias. Comparison of plans with actual investment shows well-established patterns of differences by time of year the survey is taken, by size of firm, and by planning horizon. Corrections for such systematic bias are based on median ratios in the preceding 8 years of plans (uncorrected) to actual investment. The median ratio is calculated separately for each industry, for each planning horizon, and for each quarter.[3] Corrected plans are equal to uncorrected plans divided by the appropriate median ratio. The data have also been seasonally adjusted, using the X–11 procedure. Plans (after bias correction) are seasonally adjusted by the factors used for actual investment.[4]

Errors in investment plans

Both planned and actual investment have had strong uptrends throughout the last 35 years, partly due to real growth and partly due to inflation. Because of these trends, a comparison of dollar levels of plans with actual investment shows a correlation that is extremely close but that is not helpful in understanding short-term movements in investment. Therefore, the comparisons in this article are based not on dollar levels, but on percent changes from lagged actual investment.[5] Transforming dollar levels into percent changes reduces correlations, but facilitates meaningful comparisons among industries of different size and among time-periods in which dollar levels differ.

Results for total nonfarm business.—Planned and actual investment for total nonfarm business, in percent change form, appear in chart 10. The top panel shows one-quarter-ahead plans and actuals as percent changes from actual investment one quarter earlier. The middle panel shows two-quarters-ahead plans and actuals as percent changes from the actual two quarters earlier. The bottom panel shows planned annual investment, as reported in February of the plan year, and actual annual investment as percent changes from the actual one year earlier.

It is clear from the chart that there are positive correlations between planned percent changes and actual percent changes in total nonfarm business investment for the entire 1957–80 period and for the two subperiods. For one-quarter-ahead plans, the simple correlation coefficient of the two series for the entire period is 0.70. For two-quarters-ahead plans, the correlation is

1. The 1980 revision, which affected both planned and actual expenditures, is described in George R. Green and Marie P. Hertzberg, "Revised Estimates of New Plant and Equipment Expenditures in the United States, 1947–77," SURVEY OF CURRENT BUSINESS 60 (October 1980): 24–50. For a thorough examination of the accuracy of plans through 1960, see Lawrence Bridge, "The Realization of Plant and Equipment Anticipations by U.S. Businessmen," paper presented at C.I.R.E.T. Conference, Paris, 1967 (unpublished). A more recent study, by Michael J. McKelvey, "The Realization of Investment Plans: A Microeconometric Approach" (Ph.D. dissertation, University of Pennsylvania, 1980), analyzes P&E expenditure plans for individual companies in three industries for 1967–77. Other studies of plans include Murray F. Foss and Vito Natrella, "The Structure and Realization of Business Investment Anticipations," in A. G. Hart, ed., *The Quality and Economic Significance of Anticipations Data* (Princeton: Princeton University Press, 1960), pp. 387–403 and Irwin Friend and Jean Bronfenbrenner, "Plant and Equipment Programs and Their Realization," in *Short-Term Economic Forecasting* (Princeton: Princeton University Press, 1955), pp. 53–111.

2. Investment as measured by actual P&E expenditures differs from the nonresidential fixed investment component of GNP. For a discussion of the relationship between these two measures, see Green and Hertzberg, pp. 33–34.

3. In the 1980 revision of the P&E survey data, the procedure to correct for systematic bias in the early years covered by the P&E survey used data for future—as well as for past—years, because data were not available prior to 1953 for manufacturing and 1954 for nonmanufacturing. The first year for which the influence of future years on the correction factors was negligible was 1957, and, accordingly, this is the starting date of the analysis in this article.

4. For a more complete description of the plans data, including the procedure for bias correction, see Green and Hertzberg, pp. 35–36.

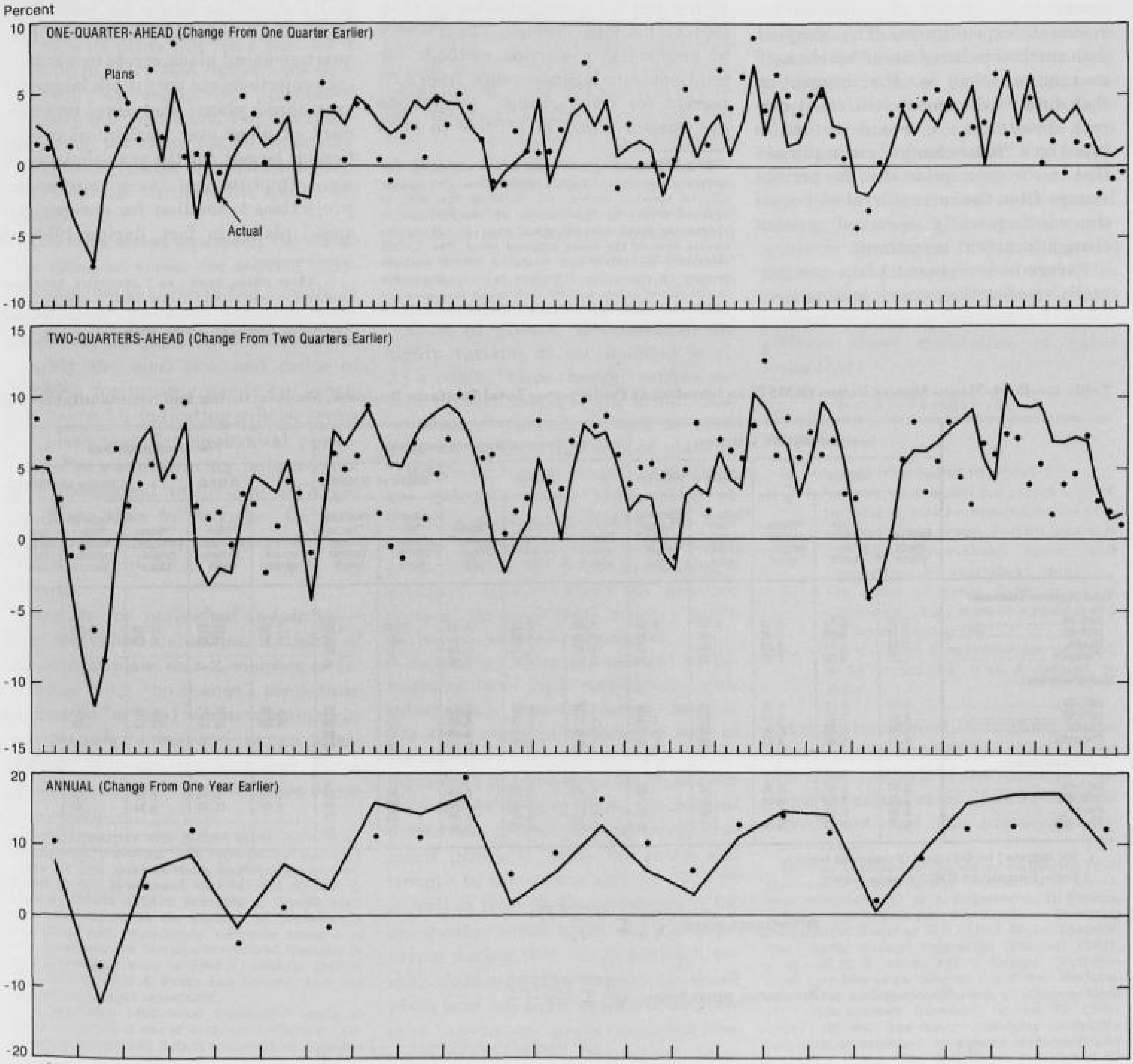
5. For example, if in quarter 1 actual investment is $100 and planned investment one quarter ahead is $103, and if in quarter 2 actual investment turns out to be $104, then the comparison in this article is of the 3-percent increase planned in quarter 1 and the 4-percent increase realized in quarter 2. If in quarter 1 planned investment two quarters ahead is $105, and if in quarter 3 actual investment turns out to be $107, the comparison is of the planned 5-percent increase and the realized 7-percent increase.

0.74; for year-ahead plans, it is 0.93. Furthermore, correlations are also positive at or near turning points in investment, represented in the chart by periods in which the solid line moves from above zero (investment growing) to below zero (investment declining) or the reverse.

Nevertheless, the chart indicates that errors in plans are at times sizeable. Actual increases substantially exceeded planned increases in 1964–65 and in the late 1970's. The annual changes in the bottom of the chart show understatements (planned below actual) of 5.9,

CHART 10

Planned and Actual Investment, Total Nonfarm Business, 1957-80



Note.—One-quarter-ahead and two-quarters-ahead actual investment and plans are seasonally adjusted. All plans are corrected for systematic bias (see text).

U.S. Department of Commerce, Bureau of Economic Analysis

81-10-10

5.4, 4.6, and 3.5 percentage points in the years 1962, 1963, 1964, and 1965, respectively; and they show understatements of 4.3 and 4.4 percentage points in 1978 and 1979. In contrast, planned investment changes exceeded actual changes in 1958, 1968, 1971, and 1972.

Comparisons with mechanical projections.—It is useful to compare the errors in plans with the errors that arise from mechanical methods of projecting investment expenditures. The simplest such method is based on a "no-change" assumption—that is, the assumption that future investment will equal current investment. A second method is based on a "same-change" assumption—that is, the assumption that the percent change from the current level will equal the most recently observed percent change in actual investment.

Errors in investment plans are generally smaller than errors arising from these mechanical projection methods for total nonfarm business and for manufacturing and nonmanufacturing. Table 1 presents this finding, using the root-mean-square error (RMSE) as a measure of error.[6] For total nonfarm business, the RMSE's of plans range from 2.17 percent for one-quarter-ahead plans in 1970–80 to 3.93 percent for year-ahead plans in 1957–69. RMSE's of plans are generally larger for manufacturing and for nonmanufacturing than for total nonfarm business. The RMSE's of mechanical projection methods for total nonfarm business range from 2.53 percent for "same-change" projections one quarter ahead in 1970–80 to 11.83 percent for "no-change" projections one year ahead in 1970–80.

The table also shows ratios of the RMSE's of investment plans to the RMSE's arising from mechanical projection methods.[7] The lower these ratios, the more accurate plans are relative to mechanical projection methods. The ratios tend to be lowest for year-ahead plans. While errors in plans are generally somewhat larger for year-ahead plans than for one-quarter- or two-quarters-ahead plans, errors in mechanical projections are very much larger for year-ahead plans; therefore, improvement of plans over mechanical projections is largest for the year-ahead horizon. Improvement over mechanical projections is smallest for one-quarter-ahead plans; in fact, during 1970–80,

6. A root-mean-square error is calculated by (a) squaring the error for each observation, (b) adding all the squared errors, (c) dividing the sum of squared errors by the number of observations to obtain the mean squared error, and (d) taking the square root of the mean squared error. The RMSE resembles an arithmetic mean of errors without respect to sign; the difference is that dispersion in the size of errors around their mean increases the RMSE but does not increase the arithmetic mean without respect to sign.

7. These ratios, known as U statistics, have been analyzed extensively by Henri Theil in *Applied Economic Forecasting* (Amsterdam: North Holland Publishing Company, 1966), chap. 2.

Table 1.—Root-Mean-Square Errors (RMSE) in Investment Projections: Total Nonfarm Business, Manufacturing and Nonmanufacturing

	One-quarter-ahead projections					Two-quarters-ahead projections					Year-ahead projections				
	RMSE			Ratios of RMSE's		RMSE			Ratios of RMSE's		RMSE			Ratios of RMSE's	
	Investment plans	"No-change" projections	"Same-change" projections	Plans to "no-change" projections	Plans to "same-change" projections	Investment plans	"No-change" projections	"Same-change" projections	Plans to "no-change" projections	Plans to "same-change" projections	Investment plans	"No-change" projections	"Same-change" projections	Plans to "no-change" projections	Plans to "same-change" projections
Total nonfarm business:															
1957–69	2.24	3.15	2.73	0.71	0.82	2.47	4.93	3.72	0.50	0.66	3.93	10.07	11.13	0.39	0.35
1970–80	2.17	3.30	2.53	.66	.86	2.73	6.19	4.14	.44	.66	2.94	11.83	6.67	.25	.44
Peaks	2.11	3.21	2.82	.66	.75	2.42	6.12	3.63	.40	.67					
Troughs	1.95	2.50	2.62	.78	.74	3.21	4.27	5.35	.75	.60					
Manufacturing:															
1957–69	3.76	4.72	3.80	.79	.99	5.63	8.88	7.90	.64	.71	6.05	14.75	18.32	.41	.33
1970–80	3.41	4.27	3.04	.80	1.12	4.13	8.13	5.58	.51	.74	5.30	15.32	11.15	.34	.47
Peaks	2.24	4.58	2.90	.49	.77	2.48	9.44	4.96	.26	.50					
Troughs	4.11	4.80	3.67	.86	1.12	7.99	9.00	8.05	.89	.99					
Nonmanufacturing:															
1957–69	2.77	3.05	3.34	.91	.83	4.90	5.99	6.44	.81	.77	4.60	8.46	9.26	.54	.50
1970–80	2.05	3.20	2.76	.64	.74	3.12	5.90	4.16	.53	.75	2.68	11.23	5.88	.24	.46
Peaks	2.88	2.93	3.17	.98	.91	3.00	4.97	4.09	.60	.73					
Troughs	1.75	2.62	2.96	.67	.59	2.80	3.76	5.60	.74	.50					

1. See footnote 7 for definitions of peaks and troughs.

NOTE.—Formulas for RMSE's are as follows:

Investment plans $$\sqrt{\frac{1}{n}\Sigma\frac{(I_{t-s}-I_t)^2}{I_{t-s}}}$$

No-change projections $$\sqrt{\frac{1}{n}\Sigma\frac{(I_t-I_{t-s})^2}{I_{t-s}}}$$

Same-change projections $$\sqrt{\frac{1}{n}\Sigma\left[\left(\frac{I_t-I_{t-s}}{I_{t-s}}\right)-\left(\frac{I_{t-s}-I_{t-2s}}{I_{t-2s}}\right)\right]^2}$$

where n=number of observations; s=length of lags (one quarter for one-quarter-ahead projections, two quarters for two-quarter-ahead projections, and one year for year-ahead projections). See text for definitions of I_{t-s} and I_{t}.

plans for manufacturing do not represent any improvement, on the average, over "same-change" projections, as the ratio of 1.12 shows. Errors in year-ahead plans during 1970–80, in contrast, have a ratio to "same-change" errors of only 0.47.

Comparison of the 1970–80 and 1957–69 periods shows no overall pattern of higher or lower ratios of RMSE's of investment plans to the RMSE's arising from mechanical projection methods. RMSE's of plans fall from 1957–69 to 1970–80 in every case, but in some cases RMSE's of mechanical projection methods fall even more. For nonmanufacturing, the ratios are all lower during 1970–80, but for manufacturing and total nonfarm business, the results are mixed.

The table shows separately the errors and ratios of errors for selected quarters designated as peaks and troughs in investment.[8] These results resemble the results for all quarters. RMSE's are of roughly the same size, and ratios of RMSE's for turning points are generally below 1.0, indicating smaller errors for plans than for mechanical projections. For manufacturing, improvement over mechanical projections is larger for peaks than for troughs; for nonmanufacturing, improvement over mechanical projections is larger for troughs.

Results for individual industries.—For individual industries, RMSE's of investment plans do not compare as favorably with "no-change" projections as they do for total nonfarm business or for manufacturing and nonmanufacturing.[9] For one-quarter-ahead plans, as shown in table 2, most ratios of errors in individual industry plans to errors in "no-change" projections tend to fall in the 0.90 to 1.10 range, both for 1957–69 and for 1970–80. Half of the ratios exceed 1.0, indicating no improvement over mechanical projections. In contrast, the ratios for total nonfarm business are 0.71 for 1957–69 and 0.66 for 1970–80. For two-quarters-ahead plans the individual industry error ratios are more favorable, but still high compared with the total nonfarm business ratios. The individual ratios tend to fall in the 0.60 to 1.00 range, compared to 0.59 (1957–69) and 0.44 (1970–80) for total nonfarm business. For year-ahead plans, individual ratios tend to fall in the 0.30 to 0.70 range, compared to 0.39 (1957–69) and 0.25 (1970–80) for total nonfarm business. The ratios for total nonfarm business tend to be lower mainly because errors in investment plans have some tendency to cancel out between industries.

Rates of growth of investment are highly variable at the industry level. As a result, "same-change" projections tend to have much larger errors than "no-change" projections and, as table 2 shows, ratios of RMSE's of plans to RMSE's of "same-change" projections are generally lower than ratios of RMSE's of plans to RMSE's of "no-change" projections. "Same-change" projections are not nearly as exacting a standard against which to measure plans at the individual industry levels as they are for broad aggregates.

Summary.—Planned changes in investment have high correlations with subsequently reported actual changes. For total nonfarm business as well as for manufacturing and nonmanufacturing, errors in plans are usually smaller than errors arising from mechanical projections of past expenditures. This result generally holds for peaks and troughs in investment and for 1970–80 as well as 1957–69. One exception is for one-quarter-ahead plans for manufacturing during 1970–80. In contrast, for individual industries one-quarter-ahead plans tend not to be any more accurate than "no-change" projections; but two-quarters-ahead and year-ahead plans generally remain more accurate than "no-change" projections.

Investment plans and other investment determinants

The investment realization function.—Many investment forecasts use plans in combination with other determinants of investment. This section reports on results for a number of such "realization functions," with special attention to the years since 1970 and to predictions for 1980.

The idea underlying the investment realization functions reported here is that actual investment reflects not only previously reported plans but also unexpected developments that have affected the demand for capital goods since the plans were formulated. For example, actual investment might tend to exceed plans when actual sales exceed sales expectations.[10] Unexpected movements in profits, in investment goods prices, or in financing costs might also cause actual investment to deviate from plans. In mathematical terms, this hypothesis about realization of plans states that:

$$(1) \qquad I_t = {}_tI_{t-\theta} + c(X_t - {}_tX_{t-\theta})$$

where:

I_t = actual investment in period t;
${}_tI_{t-\theta}$ = investment planned for period t, as of period $t-\theta$, with θ = one quarter for one-quarter-ahead plans, θ = two quarters for two-quarter-ahead plans, and θ = one year for year-ahead plans;
X_t = the value of some determinant of investment, e.g., sales or a price index for investment goods;
${}_tX_{t-\theta}$ = the value of X expected for period t, as of period $t-\theta$, with θ defined as above.

Actual investment, according to the equation, is equal to planned investment plus some function of the difference between the actual value of an investment determinant and the previously ex-

8. Peak quarters were defined as the quarters at, immediately preceding, and immediately following peaks in real total nonfarm business investment. Peaks in real investment were in 1957:2, 1960:2, 1966:4, 1969:3, 1974:2, and 1980:1. Trough quarters were defined as the quarters at, immediately preceding, and immediately following troughs in real total nonfarm business investment. Troughs in real investment were in 1958:4, 1961:2, 1967:4, 1971:1, and 1975:4. Peaks and troughs were not defined for annual investment.

9. The term "individual industries" refers to those in table 2, a mix of Standard Industrial Classification 2-digit and 3-digit groupings of manufacturing and nonmanufacturing activities. Each firm in the P&E survey sample is assigned to one industry on the basis of its principal activity (measured by sales).

10. Two examples of the use of realization functions are in Robert Eisner, "Realization of Investment Anticipations," in J. Duesenberry, G. Fromm, L. Klein, and E. Kuh, eds., *The Brookings Quarterly Econometric Model of the United States* (Amsterdam: North Holland Publishing Company, 1965), p. 97 and F. G. Adams and V. Duggal, "Anticipations Variables in an Econometric Model: Performance of the Anticipations Version of Wharton Mark III," *International Economic Review* 15 (June 1974): 207–224. The theory underlying realization functions is developed in Franco Modigliani and Kalman J. Cohen, "The Significance and Uses of Ex Ante Data," in M. J. Bowman, ed., *Expectations, Uncertainty, and Business Behavior* (New York: Social Science Research Council, 1958), pp. 151–64.

pected value of that determinant. The equation is written in terms of only one investment determinant, but three such determinants will be tested—namely, real final sales, after-tax profits, and the price of investment goods.

The widely used neoclassical theory of investment demand focuses on sales and the user cost of capital as determinants of investment. The user cost of capital depends on the price of investment goods, on interest rates and other rates of return, and on the tax treatment of investment. Some tests of long-term interest rates showed that, given investment plans, unexpected interest rates were either unrelated to actual investment or related in a way opposite of that suggested by neoclassical theory. Consequently, interest rates were dropped from the analysis. The tax treatment of investment was not incorporated because there did not seem to be any realistic way to construct a quarterly measure of the tax treatment that was expected at the time plans were reported (and therefore, presumably, incorporated in plans). Realized profits are not a determinant of investment in the neoclassical theory; they were tested on the grounds that unexpectedly high or low after-tax profits affect the availability of internal funds, and hence might influence the timing of investment even if they do not influence the level of investment over long periods.

Table 2.—RMSE in Investment Projections, Individual Industries

		One-quarter-ahead projections			Two-quarters-ahead projections			Year-ahead projections		
		RMSE	Ratios of RMSE's:		RMSE	Ratios of RMSE's:		RMSE	Ratios of RMSE's:	
	Time period	Investment plans	Plans to "no-change" projections	Plans to "same-change" projections	Investment plans	Plans to "no-change" projections	Plans to "same-change" projections	Investment plans	Plans to "no-change" projections	Plans to "same-change" projections
Total nonfarm business	1957-69	2.26	0.71	0.63	3.47	0.59	0.65	3.93	0.35	0.36
	1970-80	2.17	.66	.56	2.73	.44	.66	3.34	.25	.44
Blast furnaces	1957-69	11.47	.84	.63	14.89	.73	.60	14.16	.46	.31
	1970-80	9.88	.97	.65	12.51	.75	.73	11.09	.49	.46
Nonferrous metals	1957-69	12.61	1.12	1.07	15.29	.74	.72	10.82	.29	.26
	1970-80	8.45	.86	.69	13.28	.87	.81	5.55	.28	.27
Other primary metals	1957-69	11.06	.98	.48	12.47	.42	.31	13.07	.30	.24
	1970-80	12.12	1.02	.70	18.47	1.12	.76	11.10	.63	.56
Fabricated metal	1957-69	10.89	.91	.80	14.34	.99	.70	11.51	.71	.42
	1970-80	7.79	1.39	1.06	8.99	.96	.62	9.12	.71	.38
Electrical machinery	1957-69	9.09	1.19	1.14	11.76	.82	.85	8.74	.36	.34
	1970-80	6.41	.92	.64	8.29	.68	.73	7.78	.38	.42
Machinery, except electrical	1957-69	8.97	1.09	1.01	12.36	.88	.81	14.61	.59	.49
	1970-80	8.95	1.00	.64	12.78	.67	.72	11.97	.58	.41
Motor vehicles	1957-69	13.17	1.08	1.44	15.85	1.29	1.25	17.83	.92	.67
	1970-80	12.30	1.49	1.42	14.05	.94	.94	8.07	.32	.34
Aircraft	1957-69	11.29	.81	.88	16.39	.68	.63	18.71	.49	.37
	1970-80	11.63	.81	.80	18.77	.62	.80	22.23	.50	.67
Other transportation equipment	1957-69	18.04	.61	.39	18.74	.88	.39	14.07	.48	.37
	1970-80	20.61	1.08	.69	27.45	1.16	.59	20.83	.77	.57
Stone, clay, and glass	1957-69	10.57	1.01	.75	12.88	.80	.69	9.10	.50	.30
	1970-80	8.18	.83	.68	13.68	1.05	.96	9.16	.43	.39
Other durable goods [1]	1957-69	7.45	1.04	.83	10.02	.80	.69	9.26	.57	.58
	1970-80	6.22	1.04	.84	9.71	1.01	.81	7.19	.51	.39
Food and beverage	1957-69	7.04	1.16	.84	8.82	.97	.61	6.52	.57	.43
	1970-80	7.03	1.38	.97	8.92	1.13	.89	7.02	.59	.63
Textiles	1957-69	8.47	.97	.86	10.03	.88	.67	9.14	.35	.28
	1970-80	7.76	1.09	.98	8.49	.74	.80	8.44	.66	.43
Paper	1957-69	10.49	1.10	.81	11.17	.83	.78	9.43	.49	.39
	1970-80	8.14	1.04	1.00	7.68	.58	.60	6.61	.27	.27
Chemicals	1957-69	6.80	.98	1.00	9.76	.79	.71	8.26	.44	.34
	1970-80	6.29	1.01	1.12	8.10	.71	.89	9.63	.45	.63
Petroleum	1957-69	6.13	1.07	.77	8.68	1.08	.69	7.23	.84	.45
	1970-80	8.04	1.00	.64	8.94	.68	.63	9.42	.41	.47
Rubber	1957-69	11.34	1.09	.70	15.40	2.03	.86	10.19	.59	.38
	1970-80	6.34	.69	.58	12.24	.82	.84	10.65	.44	.37
Other nondurable goods [2]	1957-69	8.71	1.22	.84	11.25	.90	.77	9.94	.67	.59
	1970-80	7.48	.89	.67	10.28	.60	.63	8.78	.87	.68
Mining	1957-69	6.05	1.00	.73	8.60	.98	.67	7.89	.83	.69
	1970-80	6.96	.68	.75	7.74	.60	.74	6.23	.27	.40
Transportation	1957-69	4.23	.49	.37	10.38	.68	.51	9.13	.48	.32
	1970-80	7.16	.91	.57	10.68	1.13	.77	11.99	1.18	1.05
Public utilities	1957-69	4.34	.94	.81	6.06	.81	.71	5.19	.42	.65
	1970-80	4.19	1.05	.88	4.43	.68	.77	4.44	.36	.71
Wholesale and Retail Trade	1957-69	4.55	.84	.63	7.11	.98	.82	12.03	1.27	.95
	1970-80	5.11	.92	.80	6.44	.70	.67	8.76	.42	.49

1. Includes lumber, furniture, instruments, ordnance, and miscellaneous manufacturing.
2. Includes tobacco, apparel, printing and publishing, and leather manufacturing.

NOTE.—For formulas for RMSE's and ratios, see note to table 1.

No attempts were made to represent supply bottlenecks that may result in unexpected shortages or delays in the completion of investment projects, because earlier econometric studies have not found that supply conditions play a significant role in realization functions.

Consistent with the use of percent changes elsewhere in this study, it is appropriate to subtract lagged investment, I_{t-4}, from both sides of equation (1) and divide by I_{t-4}:

$$(2) \quad \frac{I_t - I_{t-4}}{I_{t-4}} = \frac{{}_tI_{t-4} - I_{t-4}}{I_{t-4}} + c\,\frac{X_t - X_{t-4}}{I_{t-4}}$$

In this form, the equation says that the percent change in actual investment is equal to the percent difference between planned investment and lagged investment plus a function of the difference between actual and expected values of the determinants of investment.[11]

Evidence of systematic bias in plans.—One of the premises underlying equations (1) and (2) is that investment plans represent, as of the time they are formulated, an unbiased forecast of what investment will actually be. The uncorrected plans, however, reveal that there are discrepancies between planned and actual investment that are so regular and pervasive that they effectively refute the premise of unbiasedness. Consideration of this evidence will lead to a modification of equation (2).

Some of this evidence appears in table 3. One piece of the evidence is the systematic bias in investment plans for firms of different size; large firms almost always invest less than planned, and small firms almost always invest more than planned. Table 3 shows a sizeable difference in average bias between large and small firms. During 1970–80 for one-quarter-ahead plans, for example, large firms spent an average of 11.2 percent less than planned, and small firms spent an average of 5.0 percent more than planned. The middle of table 3 shows the pervasiveness of this bias. In only 5.4 percent of the quarters (5 out of 92) did large firms invest more than they planned. Small firms, on the other hand, invested more than they planned in 71.8 percent of the quarters.

Another piece of evidence is persistent seasonal discrepancies between uncorrected plans and actual investment. Actual investment generally falls short of plans in the first three quarters of the year but exceeds plans in the fourth quarter. The bottom part of table 3 shows that, for one-quarter-ahead plans during 1957–80, the shortfall of actual investment below plans averaged 7.8, 4.1, and 7.3 percent during the first three quarters. If the plans reported in the P&E survey actually represent forecasts, it hardly seems possible that respondents would remain unaware of these regularly recurring discrepancies and fail to correct them.

An interpretation of these discrepancies is that the reported plans are not forecasts but rather are annual targets for major capital additions underway that are divided into quarters with little regard for seasonal influences on investment.[12] For those firms with comprehensive capital planning (this group includes many large firms), the principal source of systematic discrepancies between plans and actual investment is that the targets are not always met. For firms without comprehensive capital planning, a major cause of systematic discrepancies is the regular emergence of needs for replacement of, or for additions to, the capital stock that are not incorporated in plans.

If these are important causes of discrepancies between plans and actual investment, then it is unlikely that investment will respond to plans percentage-point for percentage-point, as assumed in equation (2). Furthermore, it is likely that some of the change in investment is neither reflected in plans nor due to unexpected movements of investment determinants. Accordingly, it is probably more realistic to estimate the strength of the response of investment to plans empirically, and to add a constant term to represent the average percent change in investment due to developments not reflected in plans.

Table 3.—Uncorrected, Not Seasonally Adjusted Investment Plans: Evidence of Systematic Bias

	Time Period	One-quarter-ahead plans	Two-quarters-ahead plans
By size of firm:[1]			
Average percent difference (actual less plans):			
All firms	1960-69	−4.0	1.1
	1970-80	−4.6	0.9
Large firms	1960-69	−9.6	−8.0
	1970-80	−11.2	−8.1
Medium firms	1960-69	−8.4	−1.0
	1970-80	−0.3	7.6
Small firms	1960-69	4.0	12.7
	1970-80	5.0	14.4
Percent of quarters actual exceeds plans:			
All firms	1960-80	33.9	54.3
Large firms	1960-80	5.4	0.5
Medium firms	1960-80	31.6	66.4
Small firms	1960-80	71.8	65.7
By quarter:			
Average percent difference (actual less plans):			
All quarters	1957-80	−4.8	0.5
First quarters	1957-80	−7.8	−2.5
Second quarters	1957-80	−4.1	−4.1
Third quarters	1957-80	−7.3	−1.4
Fourth quarters	1957-80	2.0	7.0

1. The period starts in 1960 because earlier breakdowns by size of firm are not available.

These comments apply to uncorrected, not seasonally adjusted data. They are less applicable to corrected, seasonally adjusted data, because systematic discrepancies are largely eliminated by the correction and seasonal adjustment procedures. These procedures are only approximate, however. Because they fail to remove all systematic discrepancies, it is desirable to allow for a response to plans other than one-for-one and for investment due to developments not reflected in plans. Equation (2) is therefore rewritten as:

$$(3) \quad \frac{I_t - I_{t-4}}{I_{t-4}} = a + b\,\frac{{}_tI_{t-4} - I_{t-4}}{I_{t-4}} + c\,\frac{X_t - X_{t-4}}{I_{t-4}}$$

According to equation (3), the percent change in actual investment depends on a constant term, on the planned percent change in investment (with a coefficient to be estimated), and on a function of the difference between actual and expected values of the determinants of investment.

Investment determinants.—Equation (3) lists only one determinant of investment, labeled X; but the tests below

11. The final term in the equation is the ratio of the unexpected value of an investment determinant to the level of investment. This form is used for some of the investment determinants; for others, the ratio of the unexpected value to the level of the investment determinant itself is used, i.e.,

$$c\left(\frac{X_t - X_{t-4}}{X_{t-4}}\right)$$

This alternative form permits the coefficient c to be interpreted as an elasticity.

12. This is the point of view developed in Bridge, pp. 22–24.

Table 4.—Estimates of Realization Functions

[Dependent variable: percent change in actual investment]

	Constant term	Plans [1]	"Unexpected" Value Of: Sales [2]	"Unexpected" Value Of: Profits [3]	"Unexpected" Value Of: Investment goods prices [4]	R^2	SEE	D-W
Total nonfarm business								
One-quarter-ahead plans:								
1957-79	0.553 (3.6)	0.436 (8.3)	0.676 (3.6)	0.175 (2.3)	0.932 (3.3)	0.62	1.61	1.81
1957-69	.506 (1.7)	.454 (5.3)	.960 (3.3)	.174 (2.4)	.428 (1.8)	.60	1.58	1.66
1970-79	1.309 (3.3)	.335 (3.4)	.349 (1.7)	.121 (1.6)	.935 (2.1)	.47	1.64	2.11
Two-quarters-ahead plans:								
1957-79	2.868 (4.2)	.562 (7.2)	1.329 (4.5)	.373 (6.0)	.934 (2.6)	.72	2.39	1.08
1957-69	1.872 (2.8)	.600 (8.0)	1.412 (2.5)	.410 (3.7)	−.404 (−.9)	.73	2.52	1.02
1970-79	3.390 (4.3)	.489 (4.3)	1.620 (2.8)	.378 (4.3)	1.400 (3.3)	.72	2.00	1.89
Year-ahead plans:								
1957-79	1.073 (1.2)	.786 (8.9)	.454 (.8)	.637 (3.6)	.372 (1.4)	.88	2.44	.86
Manufacturing								
One-quarter-ahead plans:								
1957-79	1.067 (2.5)	.387 (4.3)	.636 (3.0)	.164 (3.4)	1.388 (2.9)	.53	2.30	1.15
1957-69	.204 (.4)	.457 (4.2)	1.200 (3.4)	.078 (1.1)	−.166 (−.3)	.58	2.02	1.14
1970-79	1.489 (2.0)	.318 (2.4)	.401 (1.3)	.148 (2.3)	1.554 (2.6)	.45	2.49	1.30
Two-quarters-ahead plans:								
1957-79	1.334 (1.0)	.773 (7.6)	1.019 (3.2)	.221 (3.3)	1.022 (1.7)	.65	4.24	.70
1957-69	−.047 (−.1)	.915 (7.2)	1.741 (3.0)	.188 (2.0)	−3.450 (−2.8)	.73	4.30	1.04
1970-79	2.943 (2.5)	.504 (3.6)	1.083 (2.3)	.301 (3.7)	2.201 (3.4)	.66	3.51	1.06
Year-ahead plans:								
1957-79	−1.079 (−.9)	1.101 (8.8)	.009 (.2)	.440 (2.0)	.547 (1.2)	.88	4.19	.94
Nonmanufacturing								
One-quarter-ahead plans:								
1957-79	1.150 (5.1)	.397 (6.4)	.732 (3.7)	.195 (1.9)	.707 (2.5)	.52	1.73	2.15
1957-69	1.111 (3.6)	.347 (4.3)	.700 (2.2)	.217 (2.1)	.661 (1.5)	.52	1.83	2.10
1970-79	1.225 (3.2)	.463 (4.4)	.780 (2.0)	.017 (.1)	.791 (1.8)	.47	1.02	2.07
Two-quarters-ahead plans:								
1957-79	4.487 (5.3)	.326 (4.8)	1.708 (5.9)	.436 (3.0)	.892 (2.8)	.50	2.50	1.15
1957-69	4.161 (0.2)	.209 (3.0)	1.534 (3.6)	.512 (2.4)	.760 (1.3)	.46	3.71	1.20
1970-79	4.677 (6.6)	.496 (4.0)	2.002 (4.3)	.277 (2.0)	1.043 (2.4)	.61	2.14	1.40
Year-ahead plans:								
1957-79	3.125 (3.4)	.522 (4.1)	1.218 (2.1)	.401 (1.6)	.388 (1.0)	.75	2.71	1.33

1. The form of the plans variable is described in the text.
2. The variable is $((S_t-S_t^e)/S_t)*100$, where S_t is real final sales and S_t^e is the expected value of S_t.
3. For one-quarter-ahead plans and two-quarters-ahead plans, the variable is $((PR_{t-1}-PR_{t-1}^e)/I_{t-1})*100$, where PR_t is after-tax profits, PR_t^e is the expected value of PR_t, and I_t is actual investment. For year-ahead plans the variable is $((PR_t-PR_t^e)/I_t)*100$.
4. The variable is $(D_t-D_t^e)$, where D_t is the percent change in the implicit price deflator for plant and equipment expenditures and D_t^e is the expected value of D_t.

NOTE.—For definitions of variables and derivation of expected values, see appendix. The t-statistics are in parentheses below the coefficients.

will use three investment determinants—real final sales, after-tax profits, and the implicit price deflator for business fixed investment.[13] The coefficients of the first two variables are expected to be positive; the coefficient of the deflator can be either positive (indicating that some or all of the unexpected price shows up in current-dollar investment) or negative (indicating that the reduction in demand in response to the unexpected price more than offsets its effect on current-dollar investment).

In order to apply equation (3), it is necessary to construct an "expected" value for each of the determinants of investment. The approach used here is to assume that the expected value of each determinant depends on its past values and on a time trend, with coefficients determined by a time-series regression analysis. For sales and profits, this model is applied to levels. For prices, the model is applied to ratios of the current implicit price deflator to last quarter's deflator. The difference between the treatment of sales and profits, on the one hand, and prices, on the other, implies that businesses form expectations about levels of sales and profits but about rates of change of prices. The appendix to this article describes in detail the procedure for, and results of, calculating expected values.

Regression results.—Results of the realization equations are reported for total nonfarm business, for manufacturing, and for nonmanufacturing in table 4. The table shows results for one-quarter-ahead, two-quarters-ahead, and year-ahead plans, with the former two shown by subperiod as well as for the entire period.[14]

Overall, the realization equations perform as expected. The coefficients for sales and profits have the expected signs and usually have t-ratios of 2 or above. (Because, as mentioned earlier, the coefficients of prices can be either positive or negative, their signs do not provide a test of the realization function approach.) Standard errors of estimates (SEE's in the tables) of the equations can be compared to the RMSE's measuring the discrepancy between investment and plans in table 1. The standard errors of estimates are always lower than the RMSE's; generally they are a great deal lower.

Most of the constant terms of the 21 equations reported in table 4 are positive and have t-ratios of 2 or above. Evidently, some portion of the growth in investment is best summarized as a constant rate rather than an amount associated with investment plans or with unexpected values of sales, profits, or prices.

Coefficients of planned changes in investment all have t-ratios greater than 2. Of the 21 coefficients for planned changes in investment, 20 are less than 1, and 10 are less than 0.5. Evidently, a 1-percent addition to plans is typically associated with something less than a 1-percent increase in investment. One of the lowest coefficients for plans applies to one-quarter-ahead plans for manufacturing in 1970–79. Heavy discounting of these one-quarter-ahead plans is consistent with their poor performance relative to mechanical projections, which was reported in the first section of this article.

Coefficients for unexpected real sales and unexpected after-tax profits are all positive and in many cases have t-ratios of 2 or above. The sales coefficients are larger for two-quarters-ahead plans than for other planning horizons. The profits coefficients tend to increase with the length of the planning horizon.

Coefficients for prices are almost all larger than zero, but vary a great deal from one equation to another. Because the dependent variable in these regressions is the percent change in current-dollar investment, a coefficient of 1.0 for the unexpected price variable implies that changes in prices are reflected fully in current-dollar investment, with no reduction in real investment. A price coefficient less than 1.0 implies that an unexpected increase in prices causes some reduction in real investment.[15] A price coefficient of more than 1.0 implies, implausibly, that real investment increases in response to a price increase. There are some price coefficients of more than 1.0; but the excess of these coefficients over 1.0 is never statistically significant.[16]

Comparison of the 1970–79 regressions with the 1957–69 regressions reveals a number of systematic differences: (1) all constant terms are higher in 1970–79, (2) most plans coefficients are lower in 1970–79, and (3) all price coefficients are higher in 1970–79.

The higher constant terms probably reflect the high rate of inflation in the 1970's. An interpretation of the constant terms, as mentioned earlier, is that some portion of investment growth is best summarized by a constant term. If this portion of investment growth refers to real growth, as seems plausible, then the constant term should reflect the average rate of inflation necessary to translate it into current-dollar investment growth, the dependent variable in the equation. The constant term for each subperiod, under these conditions, will tend to be larger the higher the average rate of inflation during that subperiod.

The lower coefficients for investment plans in 1970–79 imply that a 1 percentage-point change in plans was associated with a smaller change in actual investment in the 1970's than in the 1957–69 period. The higher coefficients for prices imply less reduction in real investment in response to unexpectedly high investment goods prices. The reasons for these changes in coefficients are not clear.

Using the regression results.—The results of these realization equations can be used to predict future investment in two ways. The simplest way is to assume that actual sales, profits, and prices will equal expected values of these variables during the forecast period, and hence the unexpected terms in the equation will be zero. Predicted investment is then derived from plans by

13. The exact variables used in the regression equations are described in the appendix.

14. There are not enough annual observations to estimate usable year-ahead results by subperiod. The equations were estimated through 1979, so that they could be used to provide estimates for 1980 (see below).

15. The elasticity of real purchases with respect to prices is equal to the price coefficients reported in the tables minus 1.0. A negative price coefficient therefore implies a price elasticity less than −1.0.

16. The test for the significance of a coefficient compared to 1.0 (rather than the usual tests compared to zero) is performed by calculating a ratio whose numerator is the coefficient minus 1 and whose denominator is the coefficient divided by its t-statistic. If this ratio exceeds 2, then the coefficient is significantly different from 1.0 at a 95 percent level of confidence.

Table 5.—Errors in Investment Predictions, 1970–79 and 1980

	One-quarter-ahead and two-quarters-ahead plans				Year-ahead plans			
	RMSE of investment plans 1970–79	RMSE of investment plans 1980	Standard error of realization equations 1970–79	RMSE of equation predictions 1980	RMSE of investment plans 1970–79	Actual minus planned investment change 1980	Standard error of realization equations 1957–79	Actual minus predicted investment change 1980
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
One-quarter-ahead plans:								
Total nonfarm business	2.20	1.93	1.04	0.40				
Manufacturing	3.48	3.01	2.40	1.06				
Nonmanufacturing	2.12	1.28	1.02	.62				
Two-quarter-ahead plans:								
Total nonfarm business	2.60	.67	2.00	2.81				
Manufacturing	4.25	2.67	3.61	3.44				
Nonmanufacturing	3.24	1.36	2.14	4.28				
Year-ahead plans:								
Total nonfarm business					2.90	−2.70	2.54	−1.20
Manufacturing					5.45	−.90	4.10	−1.04
Nonmanufacturing					2.48	−4.00	2.70	−3.03

1. The entries in columns 6 and 8 are single numbers rather than RMSE's because there is only one annual prediction for 1980.

using the constant term and the coefficient of the plans variable in the relevant equation.

A more complete use of the realization equations is possible if the user has independent forecasts of real final sales, profits, and investment goods prices. These forecasts may be used as if they were actual values. Expected values of sales, profits, and prices may be estimated using the formulas for expected values explained in the appendix of this article. The entire realization equation can then be used to forecast investment.

This article reports on 1980 predictions using the simpler method. For one-quarter-ahead and two-quarters-ahead predictions, predictions are based on the equations for 1970–79 reported in table 4. For year-ahead predictions, where no equations are reported for 1970–79, predictions are based on equations for the entire 1957–79 period.

The results, shown in table 5, indicate that the equations lead to fairly accurate predictions in 1980. For one-quarter-ahead plans, the RMSE's of equation-based predictions (column 4) are smaller than other errors in the table—the 1970–79 RMSE's of plans (column 1), the 1980 RMSE's of plans (column 2), and the standard error of the 1970–79 realization equations (column 3). For two-quarters-ahead plans, the 1980 predictions are less successful; the prediction errors in column 4 are sometimes larger than and sometimes smaller than other errors. Year-ahead predictions are more successful than two-quarters-ahead predictions. Prediction errors for 1980 (column 8) are smaller than 1970–79 errors in plans (column 5) and standard errors of realization equations for total nonfarm business and manufacturing (column 7). The predictions from the annual equations are considerably better than the plans (column 6) for total nonfarm business and nonmanufacturing but not for manufacturing.

Summary.—Investment realization equations, relating actual investment changes to planned changes and to unexpected movements in sales, after-tax profits, and prices, performed well for total nonfarm business, manufacturing, and nonmanufacturing. Coefficients relating actual investment changes to planned changes were almost always less than 1.0, indicating that a 1-percent addition to plans is typically associated with less than a 1-percent increase in actual investment. Coefficients for sales, after-tax profits, and prices were generally positive. Predictions for 1980 based on use of truncated realization equations were fairly accurate, more so for one-quarter-ahead plans and year-ahead plans than for two-quarters-ahead plans.

APPENDIX: Estimating Unexpected Values of Investment Determinants

ESTIMATES of the unexpected value of each investment determinant were derived from the equations relating expected value to a weighted average of past values and a time trend. After these equations were estimated, the unexpected value of each investment determinant was calculated as the actual value less the expected value.

The investment determinants for which expected and unexpected values were constructed were real final sales, profits, and investment goods prices. The variables were:

- *for total nonfarm business:* final sales in constant (1972) dollars, domestic profits after tax of nonfinancial corporations, and implicit price deflator for P&E expenditures by total nonfarm business.[17]
- *for manufacturing:* final sales of goods in constant (1972) dollars, domestic profits after tax of manufacturing corporations, and implicit price deflator for P&E expenditures by manufacturing industries.[17]
- *for nonmanufacturing:* final sales in constant (1972) dollars domestic profits after tax of nonfinancial nonmanufacturing corporations, and implicit price deflator for P&E expenditures by nonmanufacturing industries.[17]

17. The price series used was a preliminary version of the one published in Michael J. McKelvey, "Constant-Dollar Estimates of New Plant and Equipment Expenditures in the United States, 1947–80" in the September 1981 SURVEY.

The estimating equation for each investment determinant expresses the value of a variable, X, as a function of past values and a time trend, as follows:

$$\text{(A1)}\quad {}_tX^e_{t-1} = a e^{bt} X^{\lambda}_{t-1} X^{\lambda^2}_{t-2} X^{\lambda^3}_{t-3} \ldots$$

where:

${}_tX^e_{t-1}$ = the value of X expected in period t, as of period $t-1$;
e = the base of natural logarithms,
t = time, with 1 in 1952:1, 2 in the following quarter, etc.,
X_{t-i} = the actual value of X in period $t-i$; with $i=1, 2, 3$, etc.,
a, b, λ = parameters to be estimated.

The value of a is expected to be positive and λ is expected to lie between 0 and 1.0. The weights for past values of X decline the longer the lag; the dots at the end of the equation indicate continuing lagged values with higher powers of λ as exponents.

To estimate equation A1, the actual value of X_t is substituted for the expected value (${}_tX^e_{t-1}$) and an error term, U_t, is added to the equation. This substitution rests on the assumption that expectations are formed in a manner that avoids bias. Making the substitution and taking logarithms of both sides leads to:

$$\text{(A2)}\quad \ln X_t = \ln a + bt + \lambda \ln X_{t-1} + \lambda^2 \ln X_{t-2} + \lambda^3 \ln X_{t-3} \ldots + \ln U_t$$

where ln denotes the natural logarithm of a variable. Writing this equation for the previous period and multiplying each term by λ gives:

$$\text{(A3)}\quad \lambda \ln X_{t-1} = \lambda \ln a + \lambda b(t-1) + \lambda^2 \ln X_{t-2} + \lambda^3 \ln X_{t-3} + \ldots + \lambda \ln U_{t-1}$$

Subtracting (A3) from (A2) leads to:

$$\text{(A4)}\quad \ln X_t = (1-\lambda)\ln a + \lambda b + (1-\lambda)bt + 2\lambda \ln X_{t-1} + V_t$$

where V_t is equal to $\ln U_t - \lambda \ln U_{t-1}$ and is assumed to have zero mean and to be serially independent.

Equation (A4) was estimated separately for each investment determinant, using ordinary least squares. For real final sales and for after-tax profits, X and X^e refer to actual and expected levels. For prices, X and X^e refer to ratios of the current value to last quarter's value.

Table 6.—Equations for Estimating Expected Values of Sales, Profits, and Price Change

	Estimated coefficients			Derived parameters			
	$(1-\lambda)\ln a+\lambda b$	$(1-\lambda)b$	2λ	a	$1000b$	λ	R^2
Real final sales:[1]							
Total	0.628 (1.6)	0.000390 (1.6)	0.953 (32.1)	3.32	0.74	0.48	0.999
Goods	.704 (2.0)	.000034 (1.9)	.937 (28.8)	4.45	.06	.47	.997
Profits after-tax:[1]							
Nonfinancial corporations	.934 (2.6)	.002029 (2.2)	.900 (25.4)	5.45	3.69	.45	.984
Manufacturing corporations	1.063 (2.8)	.002050 (3.1)	.881 (21.1)	6.57	3.68	.44	.988
Nonmanufacturing nonfinancial corporations	.711 (2.6)	.002280 (3.1)	.815 (27.6)	3.70	3.83	.40	.980
Investment goods prices:[1,2]							
Total nonfarm business	−.000061 (.1)	.000062 (3.3)	.649 (9.6)	1.00	.09	.32	.677
Manufacturing	.000101 (.1)	.000040 (2.4)	.716 (10.8)	1.00	.06	.36	.637
Nonmanufacturing	−.000535 (.4)	.000079 (2.2)	.547 (9.9)	1.00	.11	.27	.497

1. For definitions and variables, see appendix.
2. For the price equations, the dependent variable is the ratio of current to lagged price level and the coefficient 2λ applies to last period's ratio.

NOTE.—The estimation period is 1952–1970.

Regression results are shown in table 6. The constant term in these regression equations is an estimate of

$$(1-\lambda)\ln a + \lambda b;$$

the coefficient of time, an estimate of $(1-\lambda)b$; and the coefficient of $\ln X_{t-1}$, an estimate of 2λ.

To use the results to estimate expected values of X_t, or ${}_tX^e_{t-1}$, it was assumed that actual and expected values were equal in an initial quarter—the fourth quarter of 1951. Then the logarithm of the expected value was generated sequentially by applying the formula:

$$\text{(A5)}\quad \ln {}_tX^e_{t-1} = ((1-\lambda)\ln a + \lambda b) + (1-\lambda)bt + \lambda \ln {}_{t-1}X^e_{t-2} + \lambda \ln X_{t-1}$$

which can be derived from (A1) by the algebraic procedure used to transform (A2) into (A4).

For the one-quarter-ahead realization equations, unexpected values of sales, profits, and prices were calculated as actual sales, profits, and prices less the expected values generated by the equations in table 6. For the two-quarters-ahead realization equations, expected values two quarters ahead were generated by applying equation (A5) twice, the first time to generate expected values one quarter ahead and the second time, letting expected values one quarter ahead serve as both lagged expected values and lagged actual values, to generate expected values two quarters ahead. Unexpected values were calculated as actual values less two-quarters-ahead expected values.[16] For the year-ahead realization equations, expected values were generated by applying equation (A5) four times and then averaging the four expected values to obtain year-ahead averages.

16. For profits, one-quarter-ahead unexpected values were much more closely related to investment than two-quarters-ahead values. Consequently, as noted in table 4, the two-quarters-ahead realization equations make use of unexpected profits one quarter ahead rather than two quarters ahead.